Axle Rank Calibration and Axle Type Calibration, New Tools to Improve the Accuracy of Pavement Portable WIM Systems

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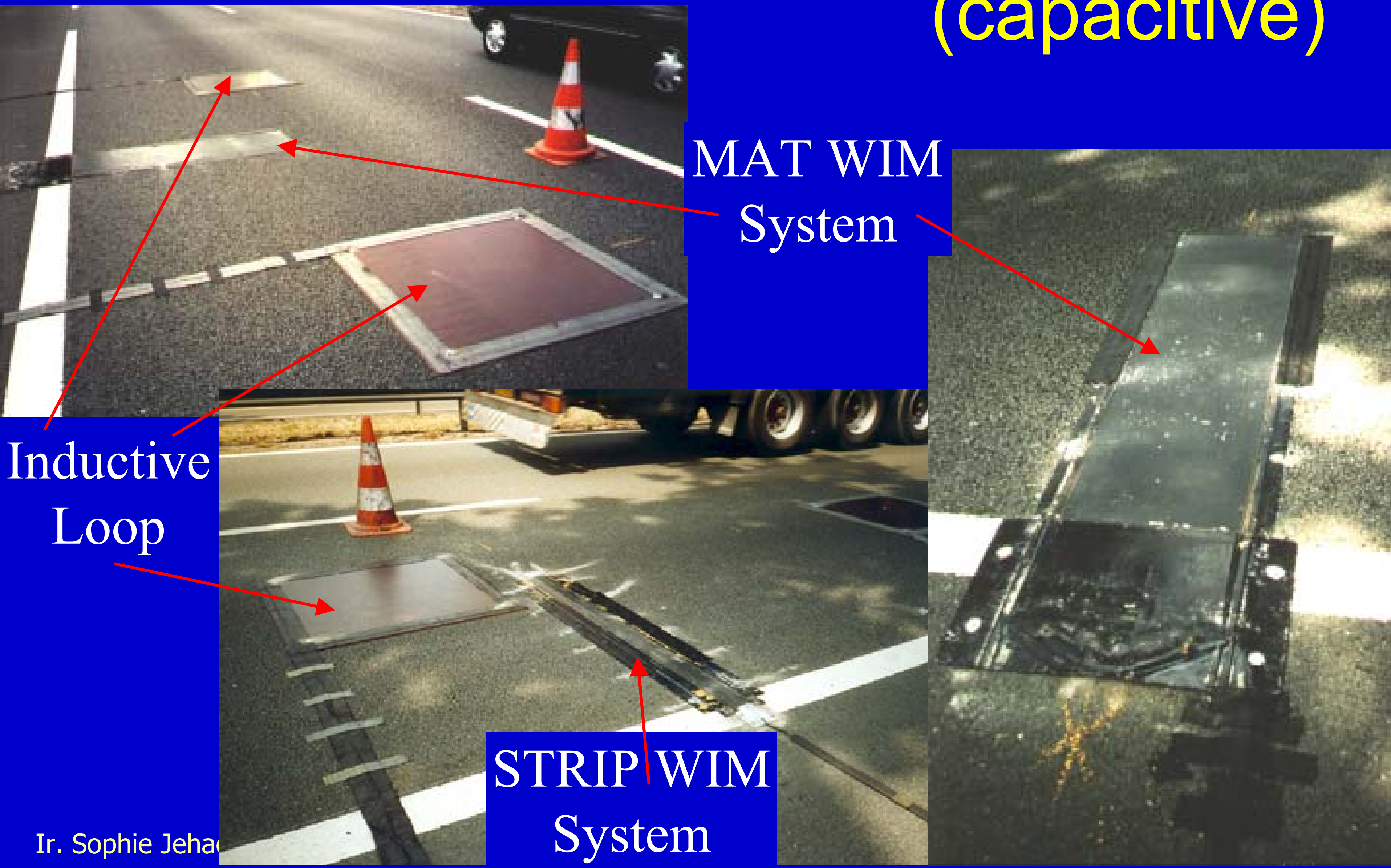
Portable Pavement WIM System

- Definition: a WIM system laid on the road surface (screwed onto the pavement or glued at the surface).
- Characteristics compared to fixed WIM system:
  - weaker lifetime,
  - equivalent accuracy,
  - usable on other roads than motorways.
- Description: 1 (or 2) weighing sensor(s) & 2 (or 1) inductive loop(s) connected to data acquisition unit.
- Technology: piezo-polymer or piezo-resistive tubes & capacitive mats or strips.

MAT System and STRIP System (capacitive)



Main Constraints

- Duration of measurement < 1-2 weeks.
- Installation/removing < 1 hour with 2-3 people.
- Punctual measurement shots through a network, not fully equipped with fixed systems.
- System above the road may induce some noise disturbances & additional dynamic interactions (it looks like a small hump for a truck). That limits the possible accuracy.

Major Applications

- Traffic statistics (control, management, prediction, frequency or classification distribution, …).
- Studies (economical, environmental, safety).
- Pavement design analysis.
- Finding future weighing locations for enforcement.
- Direct pre-selection.
- <u>Never</u> for load enforcement and economical applications, <u>except</u> if available accuracy satisfies both legal authorities & users.

Manual Calibration Procedure

- Calculation of the calibration parameters:
  - rented test vehicle(s) make(s) several passes on the road (at least 10 runs),
  - disadvantages: time and cost.
- Implementation of the calibration parameters:
  - after the measurements,
  - directly into the data file,
  - during measurement: system is at 100 % of its sensitivity range and no disturbance of the normal traffic during the calibration phase.

Calibration Formulae

- Calibration on the mean square error:

$$C = \frac{\sum_i n_i W s_i^{\,2}}{\sum_{i,k} W s_i W d_{ik}}$$

- Calibration by lorry type:
  - one calibration coefficient for each type (silhouette) of lorry (rigid lorry, tractor + semi-trailer, lorry + trailer).
- Calibration by axle rank:
  - one calibration coefficient for each rank (and/or type) of axle within a lorry.

Test Description

- System: capacitive mat (MAT) and capacitive strip (STRIP) (did not work properly).
- On highway RN10 (2x2 lanes) near Paris (France).
- Heavy traffic (30,000 vehicles/day - 25 % of trucks).
- Pavement characteristic = ‘good’ site (class II).
- Test (3 days) during a sunny week.
- Two test populations:
  - 2 test vehicles (special 2-axle rigid truck (> 13 tons for 2nd axle) and 5-axle semi-trailer with various loads),
  - pre-weighed vehicles taken from the traffic flow and statically weighed.

Analysis Procedure

- Calibration factors assessed to work at maximal possible sensitivity range (100 %).
- Calibration factors based on test vehicles.
- Accuracy defined by measuring 2nd population (pre-weighed vehicles) calibrated with those values (Full reproducibility conditions R2).
- Elimination of outliers after visual control on site (vehicle passing partially off-road, flat tyre, people stepping on transmission cable, …) or after statistical test, such as Dixon's test.

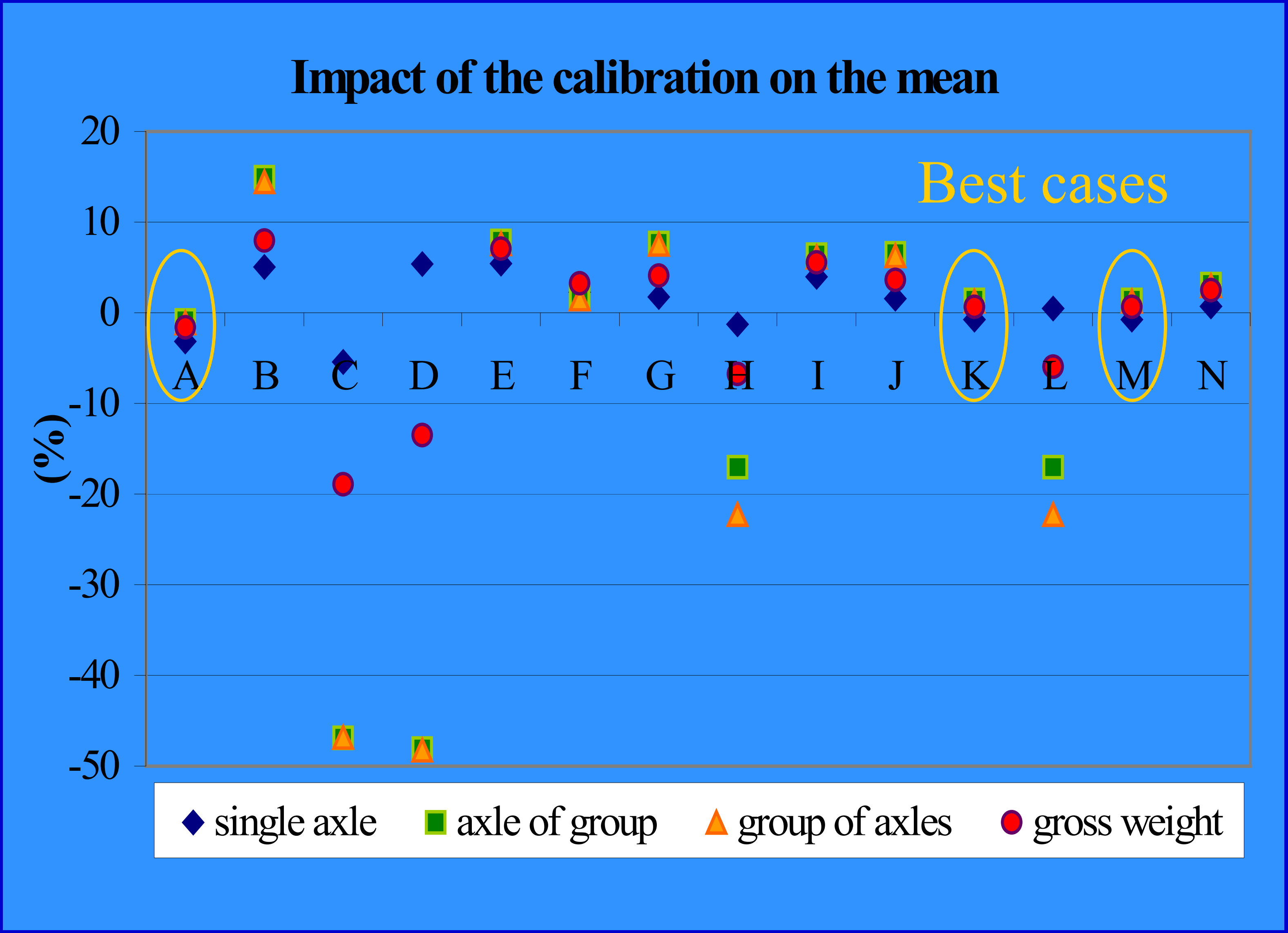
Considered Calibration Methods - I

Based on	Using values of	Nber of calib. factor	#
2 -axle truck	gross weight	1	A
	axles all together	1	B
	axles per position/rank	2 (for 1st & 2nd axle) (*)	C
	axles per type	1 (for single axles) (*)	D
5-axle semi-trailer	gross weight	1	E
	axles all together	1	F
	axles per position/rank	5 (for 1st, 2nd, 3rd, 4th, & 5th axle) (*)	G
	axles per type	2 (for single axles and tridem axles) (*)	H

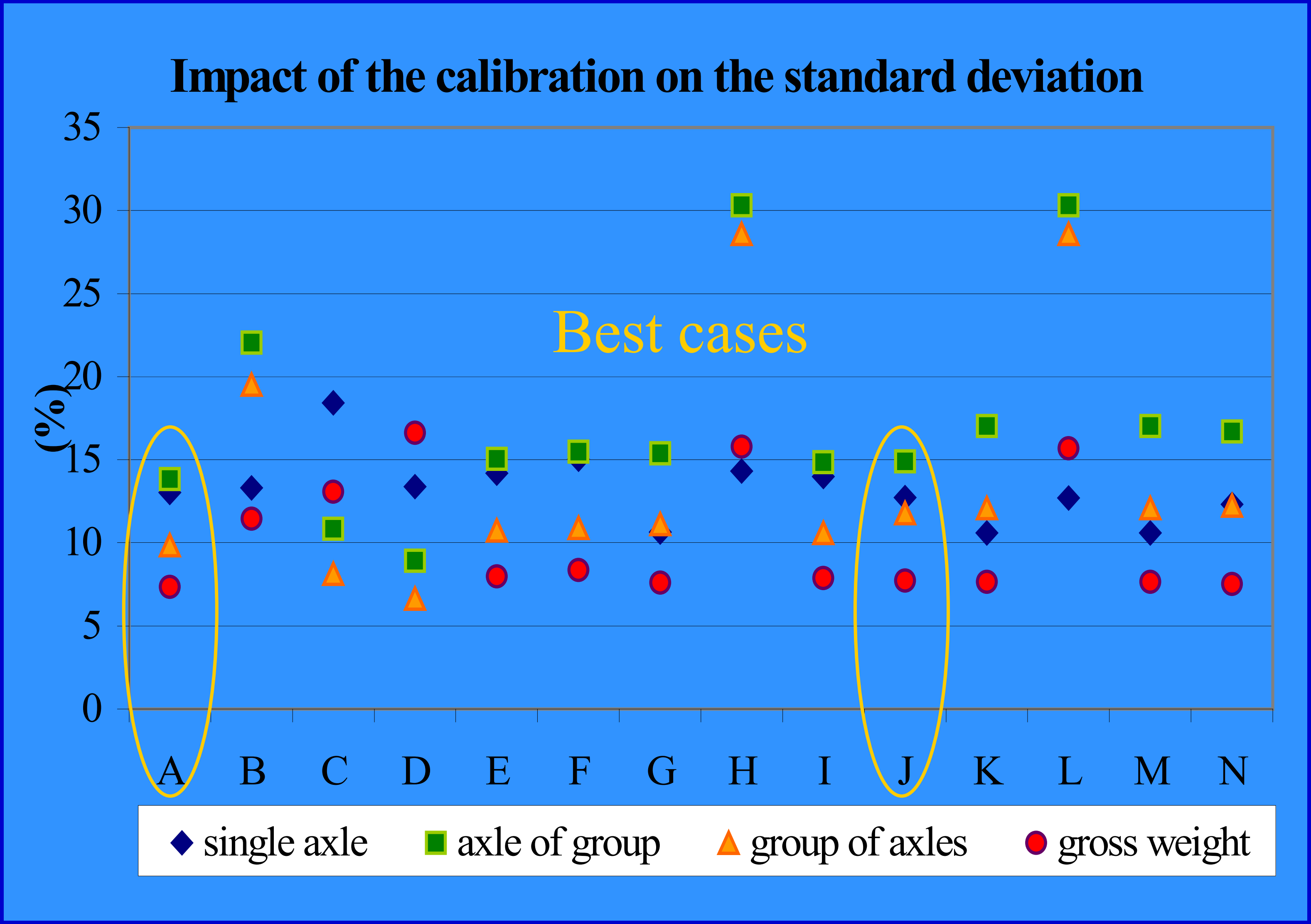
Considered Calibration Methods - II

Based on	Using values of	Nber of calib. factor	#
2 -axle truck and 5-axle semi-trailer	gross weight	1	I
	axles all together	1	J
	axles per position/rank	5 (for 1st, 2nd, 3rd, 4th, & 5th axle) (*)	K
	axles per type	2 (for single axles and tridem axles) (*)	L
	axles per position/rank	9 (average of the first five axles' values is used as value for other axles)	M
	axles per type	3 (value for tridem axles is used for tandem axles)	N

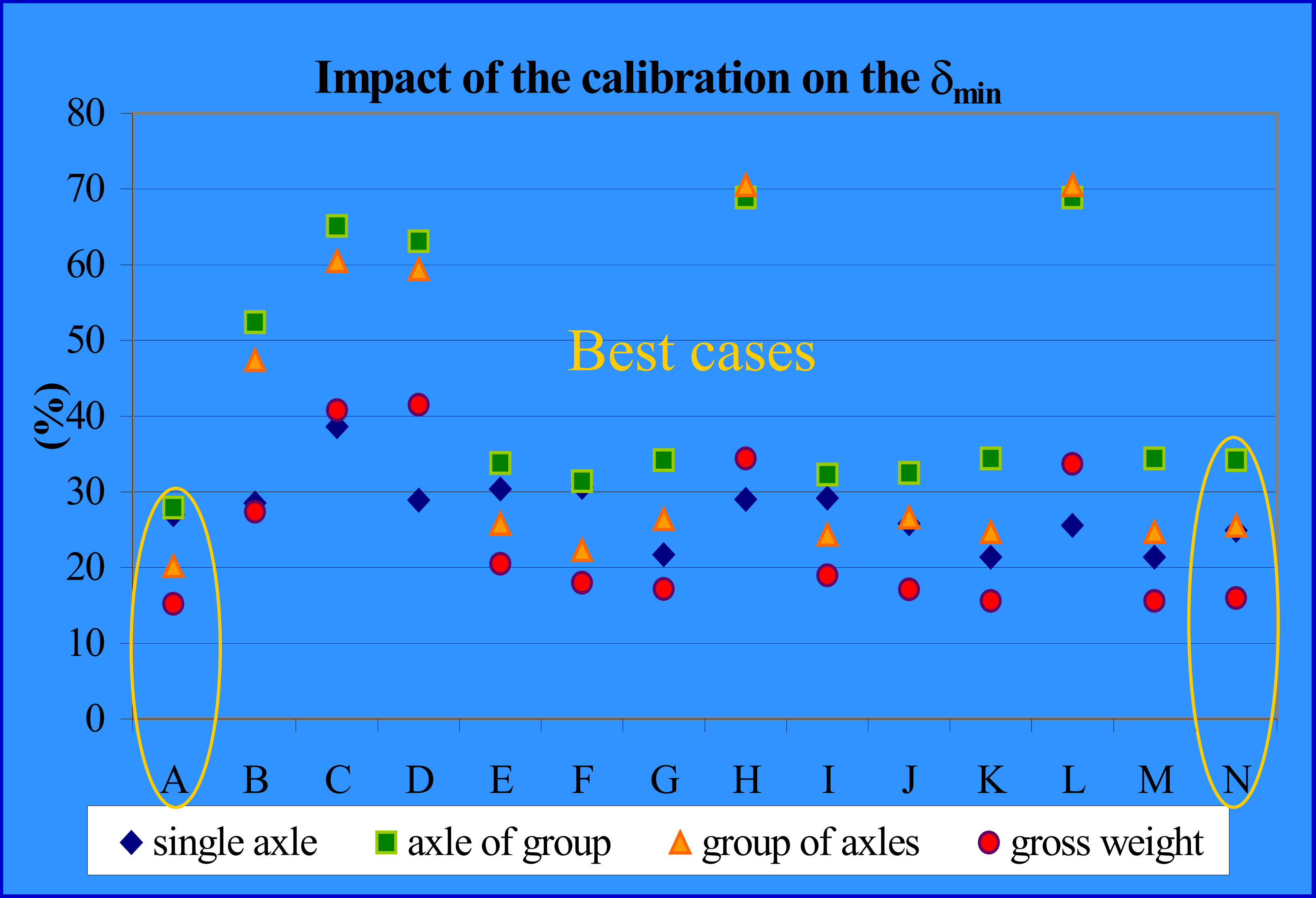
Results for the MAT System - I



Results for the MAT System - II



Results for the MAT System - III



Some Explanations

Strange and unclear results, due to:

- Type of test vehicle:
  - 2-axle truck has a 2nd axle > 13,5 tons.
- Average weights of pre-weighed population:
  - 2-axle population has an average GW of 11,8 tons (less than the 2nd axle load of the test vehicle),
  - Average weight of the single axles of the pre-weighed vehicle population is about 6,8 tons.

Results were corelated with tests in Belgium:

- Same shape but worth accuracy.

Possible Application - I

Calibration factors are slightly independent of test site:

- If test sites belong to same quality class.
- If use of identical test vehicle.
- For MAT System: calibration factor based on GW varies between 1,76 & 1, 86.

If calibration factor based on single axle is constant.

We assume that calibration factor based on a tridem axle (F_{TT}) is also constant and will slightly vary in the same amplitude as for the single axle (F_{SA}).

Possible Application - II

- If we know (F_{SA_A}) for site A and B (F_{SA_B}),
- If we know (F_{TT_A}) for site A,
- Then we could write: $F_{SA\_A} / F_{SA\_B} = F_{TT\_A} / F_{TT\_B}$
- $\Rightarrow F_{TT\_B} = F_{TT\_A} * F_{SA\_B} / F_{SA\_A}$

- One test done:
  - δ_{min} =33 for GW if calibration based on 2-axle truck
  - δ_{min} =26 for GW if calibration based on 2-axle truck & 5-axle semi-trailer
  - δ_{min} =28 for GW if calculated by this method

Conclusions

- Best calibration method choice depends on the available trucks and the useful criterion.
  - Calibration by axle type: based on mix of rigid trucks & vehicles equipped with tandem or tridem axle,
  - Calibration by axle rank: each axle has a calib. value,
  - Based on special 2-axle rigid truck (with axle load higher than the normal one), on the GW criterion.
- Easily implemented in a traffic analysis software.
- Approximation of calibration factor for tandem & tridem (F_{TT_A}), based on single axles for 2 sites (F_{SA_A}, F_{SA_B}).